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Type of Organization: College or University

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Project Title: Assessment and Remediation of Hg and PCB Contamination

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 0

Total Funding Requested ($): 156,574 **Project Duration:** 2 Years

Abstract:

Mercury and PCBs have been identified as priority pollutants of concern in the Great Lakes. There is widespread occurrence of these compounds in sediments and biota of these ecosystems. These compounds have impaired beneficial uses and pose a tremendous remediation challenge. Currently, there is significant uncertainty associated with determinations of what constitutes "clean" or "contaminated" sediments and whether sediment capping via open-lake disposal can reduce ecosystem contamination by Hg, PCBs and other sediment contaminants. This project has several objectives: 1) Assess the roles of Hg and PCBs in causing beneficial use impairments in the Western Lake Erie Basin (where contamination is highest); 2) Determine the link between sediment-associated Hg and PCBs and their concentrations in lower levels of the aquatic food web; 3) Evaluate the usefulness of sediment capping (via open-lake disposal of "cleaner" sediments) for reducing contaminant uptake in the lower food web; and 4) Demonstrate an efficient, effective, weight-of-evidence approach for future determinations of "significant" sediment contamination. The products of this project will result in improved assessments with enhanced decision-making applications for dredging, remediation and ecological risk issues. This will include a guidance document on how to conduct efficient and effective assessments of sediment contamination for pre- and post-remediation and dredging projects.

Geographic Areas Affected by the Project

States:

- ☐ Illinois
- ☐ Indiana
- ☐ Michigan
- ☐ Minnesota
- ☐ New York
- ☐ Pennsylvania
- ☐ Wisconsin
- ☒ Ohio

Lakes:

- ☐ Superior
- ☐ Huron
- ☐ Michigan
- ☒ Erie
- ☐ Ontario
- ☐ All Lakes

Geographic Initiatives:

☐ Greater Chicago ☐ NE Ohio ☐ NW Indiana ☐ SE Michigan ☐ Lake St. Clair

Primary Affected Area of Concern: Maumee River, OH

Other Affected Areas of Concern: Western Basin of Lake Erie

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

Mercury and PCBs have caused extensive beneficial use impairment in the Great Lakes. The primary reservoir of these contaminants is in the sediments, which also may serve as the primary source for food web contamination. Lake Erie's western basin has many areas of contamination based on sediment quality guideline exceedances (OEPA, Env. Can., USACOE unpubl.) with beneficial use impairments and more restrictive fish consumption advisories. Currently, risk management, dredging, and remediation decisions are based on questionable data regarding critical concentrations of these contaminants. Unfortunately, there is little information on the true ecological risk (and bioavailability) of sediment-associated Hg and PCBs in Lake Erie. The limited tissue data available is for fish fillets and, therefore, only addresses human consumption concerns. The accuracy of the sediment quality guidelines is routinely questioned by the scientific community. Laboratory assessments of toxicity, uptake and chemical analyses on Great Lakes sediments have largely been too insensitive to establish whether a problem truly exists. Therefore, an improved method assessing the significance of sediment contamination is needed.

Since large areas of the basin's sediments contain elevated levels of contaminants, remediation could be extremely costly, if not impossible. Dredged materials being disposed of in the western basin are often cleaner than their adjacent reference sites. These cleaner materials could serve as capping material for contaminated sites, thereby reducing ecosystem contamination. This open-lake disposal of dredged materials would be a cost-effective alternative for sediment remediation. This project will determine whether this approach has potential as an effective alternative through field and laboratory assessments.

The U.S. EPA and others have stressed that in situ toxicity studies are needed to ascertain whether sediment quality guidelines are truly significant, yet has not conducted such studies or provided guidance on how to do so. Recent studies at 7 sites across the nation by the PI (GAB) have shown in situ toxicity and bioaccumulation assessment to effectively identify primary stressors in water, surficial sediments and pore water with rapid (48 h) toxicity and bioaccumulation responses. These methods have been successfully used in stream, river, lake and ocean environments. These cost-effective studies showed a multi-species, in situ test battery to be very sensitive to PCB related toxicity (<10 mg/kg), highly correlated with significant levels of organic and inorganic (metal and ammonia) contaminants, and the realistic exposures reduced uncertainty associated with traditional assessment approaches. Given the widespread occurence of contaminated sediments and their tremendous impact on Great Lakes use attainment, it is essential that improved methods and resulting decision making be based on sound science.

This project will describe an effective assessment approach for identifying "significant" sediment contamination and its link to food web accumulation for use in remediation decisions. In addition, it will assess the potential of open-lake disposal as an adequate cap for more contamianted sediments. This project will have several outcomes and benefits:

1) Improved ecological and human risk assessments;
2) Improved assessment of the sediment contamination in the western basin of Lake Erie;
3) Improved understanding of link between sediment contamination and food chain contamination;

4) Assessment of Binational Toxics Strategy Priority Pollutants in Great Lakes sediments;
5) Improved assessment of baseline conditions for reference site determinations (e.g., for dredging applications) and remediation proposals;
6) Improved understanding of the benefits of sediment capping with cleaner dredged materials to reduce ecological risk; and
7) Provide a pilot demonstration of an improved, weight-of-evidence assessment approach that results in greater certainty for risk management decisions at less expense.

Proposed Work Outcome:

The study will utilize expertise from 3 institutions (Wright State University (WSU) (AB), Univ. of Toledo (UT) (Dr. Hans Gottgens), and Ohio Environmental Protection Agency (OEPA) (John Estenik lead)). This interdisciplinary assessment will involve characterizations of site sediment toxicity, indigenous biota, bioaccumulation and chemical concentrations in a 3-dimensional profile. Novel and traditional approaches will be used in both laboratory and field settings. Contaminated test sites will be compared to reference sites and "cleaner" dredged materials will be used as capping material for contaminated sediments. The relationship of "clean" vs. "contaminated" sediments will be established based on a weight-of-evidence determination of adverse biological effects (i.e., toxicity, depressed indigenous community, contaminant uptake). The potential for beneficial use impairment and effectiveness of sediment capping will also be established using this weight-of-evidence approach while considering vertical profiles of Hg and PCBs.

Ten sites where historical data on sediment contamination exists have tentatively been selected. Final selection will be in coordination with the OEPA and the U.S. EPA GLNPO. Tentative sites range from high quality, reference condition sites to ones contaminated with Hg and PCBs. The site sediments will share similar physical characteristics where possible.

Sediments will be collected by the OEPA, WSU, and the UT team using coring devices and clean techniques. Sediments will be subsampled at 3 depths (e.g., 0-6, 6-12 and 12-18 cm) to quantify vertical profiles of contaminants and allow for comparisons of capping effectiveness.

Sediments will be fully characterized by OEPA, WSU, and UT as follows: particle size, total organic carbon, total metals, base neutral and extractable fraction (BNAs), organochlorine pesticides, total Hg, total PCBs, and ammonia. A subset of samples will have PCB congener analyses (WSU). A subset of duplicate samples will be analyzed by UT for QA/QC comparisons.

Sediment capping will be evaluated by comparing 4 "cleaner" sediments (from areas that are dredged) and 4 contaminated sites with 2 control/reference sites. Each site will be characterized using sediment physicochemical profiles, indigenous benthic community indices, sediment toxicity and bioaccumulation measures. Capping will be simulated by covering contaminated sediments with the "cleaner dredged" sediments in both lab and field experiments.

Indigenous biota (benthic macroinvertebrates) at each site will be collected using Ponar grabs. A subsample will be identified to the lowest possible taxon. Whole tissue analyses will be conducted on 3 dominant species (e.g., zebra mussels, Hexagenia, Chironomus) by UT.

In situ toxicity and bioaccumulation studies will also be conducted at each site by WSU. Four species (Daphnia magna, Hyalella azteca, Chironomus tentans, and Lumbriculus variegatus) will be deployed in 2 exposures (water and surficial sediments). Measurement endpoints will consist of survival (daphnia, amphipod, midge), growth (midge), feeding (amphipod) and whole tissue residues (midge and worm).

These same toxicity and bioaccumulation endpoints (without daphnia) will be evaluated in the laboratory in capping experiments. Contaminated sediments will be placed in aquaria and capped with 3 different depths of cleaner dredged sediments (in triplicate). Following a 2 wk equilibration, the test organisms will be exposed in a daily static-renewal system for 2, 14, and 28 d periods.

Following the laboratory treatment evaluation of capping, a field assessment of dredged material capping will be conducted at one relatively shallow (<10 m) contaminated site. Treatments will consist of 1) uncovered, contaminated sediment, 2) thin capping with dredged material, and 3) thick capping of dredged material. The capping depth will be based on the previous laboratory evaluation, reviews of the literature for resuspension in the western basin, and discussions with USACOE personnel on feasibility. Each treatment will consist of triplicate, 1 square meter plots. Plot boundaries and

capping material will be added using WSU divers. Following a 2 wk equilibration, the above in situ test design would be conducted.

Biological profiles and responses, tissues residues and chemical concentrations in water and sediment layers will be evaluated using a weight-of-evidence approach and compared to historical data. Results will be evaluated in terms of the study objectives (see previous section).

Finally, a detailed guidance document will be prepared describing how effective, integrated assessments of sediment contamination can be conducted using this weight-of-evidence approach. This approach will represent a significant improvement over the recommendations of the GLNPO ARCS Assessment Guidance Document (1994) in which the PI (AB) lead the toxicity testing portion of the guidelines. This guidance will be directed towards improved methods of determining whether or not sediments are contaminated for dredging, remediation and ecological/human health risk assessments. In addition, it will provide ecological risk information on the effectiveness of sediment capping using open-lake disposal of dredged materials as a remediation technology.

Project Milestones:	**Dates:**
Project Start	08/2000
Finalize Stations w/ OEPA + GLNPO	09/2000
Presampling of Stations Completed	11/2000
Analyses of Presurvey Complete	03/2001
Summer Sampling Complete	09/2001
Chemical Analyses Complete	03/2002
Data Analyses Complete	05/2002
Final Report Complete. Project End.	07/2002

☐ Project Addresses Environmental Justice

If So, Description of How:

☒ Project Addresses Education/Outreach

If So, Description of How:

This project will provide useful information for the regulatory, business, and environmental consulting sectors concerning:
1) Effective methods for assessing Hg and PCB contamination (cost-efficient and reduced uncertainty);
2) Ecological risk information on true risk of Hg and PCBs in sediments of western Lake Erie;
3) Improved determinations of what constitutes an acceptable reference sediment; and
4) Improved understanding of the effectiveness of sediment capping vs. ecological risk.
This information will be supplied through a USEPA Guidance Document and peer-reviewed publications.

Graduate students (~ 6) will be involved in all phases of this project. In addition, the project and its protocols will be used to familiarize undergraduate students with environmental research.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	61,574	22,268
Fringe:	7,626	21,090
Travel:	7,535	0
Equipment:	0	0
Supplies:	14,000	0
Contracts:	2,500	0
Construction:	0	0
Other:	4,500	0
Total Direct Costs:	97,735	43,358
Indirect Costs:	58,839	11,286
Total:	156,574	54,644
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

The Ohio Environmental Protection Agency will be providing approximately 12 person days for sediment sample collection and full chemical and physical characterization of 30 sediment samples at no charge to the project.

Description of Collaboration/Community Based Support:

This project is done in collaboration of the Ohio EPA (John Estenik lead). We are also willing to collaborate with the U.S. EPA Great Lakes National Program Office if they wish to participate in sample collection and demnostration of in situ techniques. The University of Toledo and Wright State University are the two primary investigators. Dr. Allen Burton (Professor, WSU) has been involved in sediment contaminant research for the past 22 years. Dr. Hans Gottgens (Associate Professor, UT) has expertise in sediment and wetland contamination research, with a focus on mercury issues.